

LATE CRETACEOUS FOSSILS FROM THE BLUFFTOWN FORMATION (CAMPANIAN) IN WESTERN GEORGIA

By

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Introduction

The Blufftown Formation (Upper Cretaceous; Campanian) reaches thicknesses up to 180 m in the Chattahoochee River Valley, at the Georgia-Alabama border, and comprises a substantial areal outcrop; nevertheless, few good exposures of the uppermost beds are available for study in its downdip (i.e., southerly) region. In part, this is due to flooding of the river valley subsequent to construction of a dam at Fort Gaines, Georgia, which simultaneously created Lake Eufaula and drowned some of the finest Late Cretaceous fossil beds in the Southeast.

Although riverside outcrops, including the Blufftown Formation's stratotype, are largely inundated, the uppermost Blufftown is well-exposed in stream cuts which roughly parallel the formation's strike along Hannahatchee Creek in Stewart County, Georgia. Approximately 3 km of strata are exposed, and these outcrops contain rich fossil biotas (uniquely in the region) abundant vertebrate material. The fossil bone-bed overlies a prominent erosional surface, which can be traced for most of the streamside exposure. Based on its stratigraphic position above this surface, and on the style of preservation of the fossils, the bone bed is interpreted as residual phosphatic lag.

Among the more spectacular finds at the Hannahatchee Creek site are fragmentary bones of the first dinosaurs and mosasaurs that can be attributed with certainty to any Georgia collection. In addition, an *in situ* bioherm, built around interlocking shells of the distinctive large oyster, *Crassostrea cusseta* Sohl & Kauffman, 1964, is located along Hannahatchee Creek, comprising the first discovery of this geographically restricted species in life position.

The paleoenvironments represented by this outcrop may be interpreted with good precision because of the rich admixture of invertebrate and vertebrate fossils; these represent marine, nonmarine, and paralic habitats, and include taxa which are certainly in life positions (i.e., the reef-forming oysters).

Previous Work

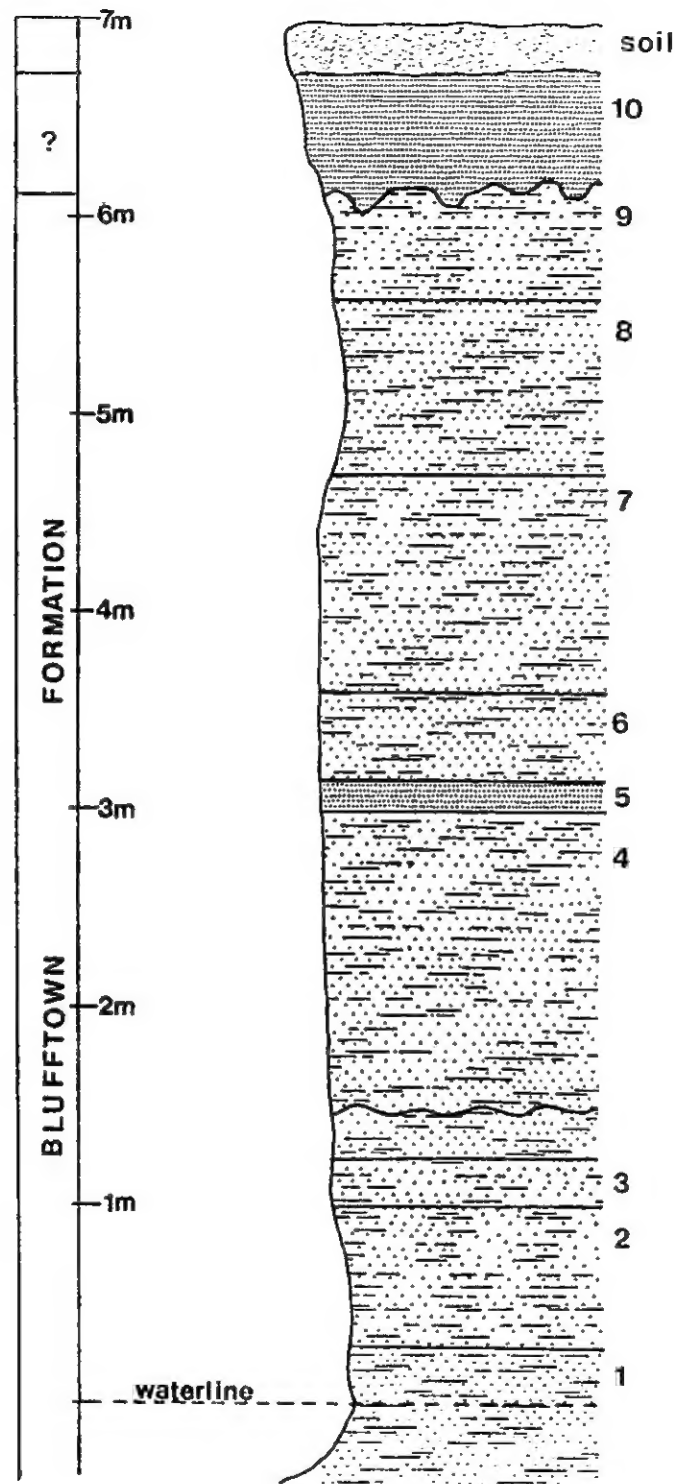
Paleontology in the Blufftown Formation has been described chiefly by Stephenson (1911). In general, the biota consists of a characteristic, diverse, Late Cretaceous *Ezogyr* *ponderosa* range-zone assemblage such as one finds in much of the Atlantic and Gulf Coastal Plains. The taxa described by Stephenson include many dozen mollusks, along with a typical shallow-water assemblage of crabs, bryozoans, trace fossils (especially *Hamulus* sp. and "*Halymenites*" [= *Ophiomorpha*] *major*), lignitized wood, and teeth from several shark taxa.

However, three elements in Stephenson's (1911) description of the Blufftown fossils are distinctive with respect to other Late Cretaceous Coastal Plain reports: the first was mention of a new and very large oyster in several downdip outcrops; second was the presence of *Ezogyr* *ponderosa erraticostata* in lieu of the smooth-shelled subspecies; and third was brief mention of fragmentary reptilian fossils. Two additional publications also mentioned vertebrate fossils from the Chattahoochee River Valley in Georgia: Cope (1878) and Hays (1907). The focus of this report will be on the three distinctive components of the fossil biotas mentioned above, and most especially, on my apparent rediscovery of a very diverse vertebrate fossil biota in the Blufftown Formation.

Figure 1. Composite section of the upper Blufftown Formation exposed at Hannahatchee Creek, 3 km west of town of Union, Stewart County, Georgia.

Unit

- 10 MEDIUM SAND, very micaceous, light brown (5 YR 6/4), iron-stained on exposed surfaces, contains lignite specks, less than 2% dark minerals.
- 9 MEDIUM SANDY CLAY, micaceous, unfossiliferous, mottled dusky yellowish brown (10 YR 2/2) and pale brown (5 YR 5/2)
- 8 SILTY, FINE SANDY CLAY; same as unit 2.
- 7 FINE TO MEDIUM SANDY, SILTY CLAY, micaceous, lignitic, fossiliferous, calcareous, medium-dark gray (N 4), may be bioturbated and shows no bedding.
- 6 SILTY, FINE SANDY CLAY; same as unit 2, except more calcareous and very fossiliferous, with common beds of mollusk hash
- 5 COARSE SAND AND *Turritella*/BIVALVE SHELL HASH, dusky yellow (5 Y 6/4), forms distinct marker horizon.
- 4 CLAYEY FINE SAND AND SILTY CLAY, micaceous, lignitic, very fossiliferous, olive-gray (5 Y 3/2). Calcareous, sandy concretions abundant throughout unit. Zones of molluscan hash locally present. Prominent erosional horizon in lower meter, traceable throughout exposure, features abundant vertebrate bones and teeth, and very-large-oyster bioherm.
- 3 SILTY, FINE SAND, micaceous, calcareous, medium gray (N 5), mollusk fragments and lignite specks in graded beds, zones of nearly pure fossil hash, dominated by *Hamulus*.
- 2 SILTY, FINE SANDY CLAY, micaceous, poorly fossiliferous, mottled olive-gray (5 Y 4/1) and light olive-brown (5 Y 5/6).
- 1 FINE SANDY CLAY, very micaceous, sticky, poorly fossiliferous, olive-gray (5 YR 3/2).



No substantial paleontological studies of the Blufftown Formation followed Stephenson (1911). Several regional guidebook and stratigraphic reports listed or mentioned fossils, but these largely repeated data from the Stephenson paper: included in this category are Cooke (1943), Herrick & LaMoreaux (1944), Eargle (1955), Richards & Hand (1958), and Marsalis and Friddell (1975). (Note, however, that the definition of the Blufftown Formation itself has changed considerably and the present usage follows Eargle, 1955.) I presented an early version of this paper (Schwimmer, 1981), which is substantially revised here. Two taxonomic papers dealing with Cretaceous oysters are also relevant to the Blufftown fauna: Stephenson (1914) formally designated the *Exogyra ponderosa* subspecies *erraticostata*, which occurs at Hannahatchee Creek; and Sohl & Kauffman (1964) formally named and systematically described the large oyster *Crassostrea cussata*, which forms the reef facies to be discussed.

Stratigraphy

The Blufftown Formation exposed along Hannahatchee Creek is grossly typical of regional Upper Cretaceous back-barrier sediments. The uppermost unit of the formation, which yields the fossils considered here, is generalized in Figure 1. Along Hannahatchee Creek, the exposed sediments are composed largely of gray to olive-green, micaceous, fine sand, silt, and marly clay, with numerous calcareous sandstone concretions. Of particular interest here is the section adjacent to the vertebrate bone-and-oyster bed (incorporating units 3 to 4 in Figure 1). These sediments suggest sizeable fluctuations of sea level, including sequences of probable storm deposits in unit 3, and the erosional surface in unit 4 indicating partial subaerial exposure.

Many upper Blufftown strata are very fossiliferous, although carbonate fossils are generally badly leached, and mollusk shells (notably gastropods, siphonate clams, and ammonites) require *in situ* hardening to recover. Many zones of finely comminuted shell "hash" can also be found, suggesting that brief periods of higher energy conditions interrupted the prevailing quiet water which deposited intact shells.

Oyster shells are often bored, apparently by sponges. Lignite is commonly found riddled by *Teredo* (shipworms). Trace fossils have not been studied in detail, but numerous tubes attributable to *Hamulus* sp. are found in high concentrations along several thin bedding planes. Also abundant are large worm tubes of the *Skolithos* type.

Paleontology

Invertebrates. The lists of fossils presented by Stephenson (1911) or Cooke (1943), from several Blufftown Formation outcrops in Stewart County, are generally adequate to delimit the invertebrate fossils at Hannahatchee Creek. Stephenson's (1911) fauna from outcrops at the town of Florence, and at Roods Creek, Georgia (exposed prior to flooding of Lake Eufaula), represent approximately the same downdip, uppermost Blufftown beds that are described here, and the list of taxa are essentially the same I have observed in the field (although many generic and specific assignments have been revised). The discussion of invertebrate fossils here will focus on two oysters, which (despite their distinctions) comprise a small portion of the biota.

The oyster bioherm mentioned previously is a rare occurrence in the Cretaceous of the Coastal Plain, and is all the more unusual in that it is built up by a most unusual organism. This oyster, *Crassostrea cusseta* Sohl & Kauffman, 1964 (see Plate 1, Figs. L, M), is among the largest of Cretaceous oyster species, reaching lengths well over 50 cm. The taxon was described originally from the Cusseta Formation in several outcrops near the study area, but the authors did note the occurrence of at least one specimen from the Blufftown Formation on the Alabama side of the Chattahoochee River. The bioherm facies observed at Hannahatchee Creek (see Plate 1, Fig. O) is the first record of *in situ* occurrence of this organism. The bioherm itself is exposed for approximately 35 m in the streamside outcrop but it forms a topographic prominence of only approximately 0.3 m above the surrounding sandstone. The oysters forming the framework are cemented to each other and other materials (including several unusually large arcoid bivalves of undetermined genus and species) in a manner very much like modern *Crassostrea virginica*; indeed, the Cretaceous bioherm very much resembles a modern oyster bed at 5X magnification!

The other notable element in the invertebrate fauna is the occurrence exclusively of *Exogyra ponderosa* var. *erraticostata*. Although *Exogyra* species are ubiquitous index fossils on the Coastal Plain, their systematics remain murky after more than 70 years of study. Based on ammonite and nannoplankton biostratigraphy (*vide* Reinhardt), the Hannahatchee Creek strata belong to the uppermost *E. ponderosa* range zone; yet, the *Exogyra*'s that one finds here are rather more similar morphologically to many specimens of *E. costata* (which comprise the next range zone) than to typical *E. ponderosa*. To date no modern, comprehensive analysis of *Exogyra* species has been attempted (Lerman, 1965, did analyze evolution among three species but he did not include *erraticostata*), and the Hannahatchee Creek specimens suggest that there are problems in delimiting the morphological limits (and, hence, ages) of *Exogyra* index species.

Vertebrates. In the "Previous Work" discussion, I listed, in addition to Stephenson (1911), two early papers which mentioned Cretaceous vertebrate fossils from the Chattahoochee River Valley. These three references comprise the existing vertebrate paleontology literature of the Blufftown. Stephenson (1911) listed the following higher vertebrate fossils which may be traced to the Blufftown Formation in Georgia:

"Fragments of the turtle *Taphrosphys* (?)
vertebra (and teeth of mosasauroid reptile
Thecachampsa rugosa Emmons (vertebra)
Polydectes biturgidus Cope (teeth)
scute of a gavial-like crocodile"
(identifications by C. W. Gilmore)

Cope (1878), in a single paragraph, reported a vertebrate fossil collection in possession of the Georgia Geological Survey, which included bones of the dinosaur "*Hadrosaurus tripes*," and the turtles *Taphrosphys strenuus*, *Amphimys ozysternum*, *Peritresius ornatus*, and *Adocus* sp. Hay (1908) reviewed the systematics of the rare side-necked turtle *Peritresius ornatus*, and included a detailed description of the specimen mentioned by Cope (1878). Hay also reported that the locality from which the *Peritresius* was collected as "Bonnahatchee Creek, Stewart County Georgia" (which does not exist on current maps and almost certainly is the site discussed here).

Unfortunately, none of the abovementioned Cretaceous vertebrate fossils from Georgia can be found in existing repositories; furthermore, none were originally illustrated in the works cited. The sole fossil mentioned above which exists in the flesh (so to speak) is the *Amphiemys* turtle carapace, which is repositied in the Georgia State Capital Museum, and is of Miocene age from Macon County. Horner (1979) published a "checklist" of eastern dinosaur fossils in museum collections, and failed to discover any material from Georgia (nor has he subsequently encountered such; 1982 personal communication). The U.S. National Museum contains neither Stephenson's nor Cope's Georgia vertebrates (R. W. Purdey, 1982 personal communication), nor are they in the Georgia Geological Survey collection (E. A. Shapiro, 1982 personal communication). To compound the problem, the taxon "*Hadrosaurus tipos*", to which Cope assigned the Georgia dinosaur material, was originally based on his misidentification of two Cenozoic white whale vertebrae from North Carolina (see Lull & Wright, 1942, and Baird & Horner, 1979); therefore, despite Cope's recognized expertise on Cretaceous dinosaurs, one is unsure precisely what he was examining in the now-vanished Georgia State Survey collections.

Fish fossils from the region have received even less detailed treatment. Stephenson (1911) identified only the following fish in the Blufftown Formation:

Lamna tezana Roemer
Otodus sp.
Corax falcatus Agassiz
Ischyrrhiza mira Leidy

No subsequent publications did other than reproduce these taxa in faunal lists.

The recent collecting, which forms the basis of this study, shows that there is a large and diverse vertebrate biota in the upper Blufftown, albeit represented by water-abraded, redeposited bone-scrap and teeth. The following list includes all vertebrate taxa discovered to date (fish identified by G. R. Case; reptiles by D. Baird and myself):

PISCES

Chondrichthyes

Selachii

(common names)

Heterodontus sp.
Hybodus sp.
Lonchidion babulskii Capetta & Case
Squalicorax kaupi (Agassiz)
Pseudocorax affinis (Agassiz)
Squatina hassel Leriche
Ginglymostoma globidens Capetta & Case
Scapanorhynchus texanus (Roemer)
Gretolamna appendiculata lata (Agassiz)
Plicatolamna borodini Capetta & Case

Port Jackson shark
hybodont shark
hybodont shark
tiger shark?
tiger shark
monk shark
nurse shark
goblin shark
mackerel shark
mackerel shark

Batoidea

Ischyrrhiza mira mira Leidy
Ptychotrygon vermiculata Capetta
Brachyrhizodus wichitaensis
Pseudohypolophus sp.
Rhombodus levis Capetta & Case

ganopristine sawfish
 gonopristine sawfish
 ganopristine sawfish?
 undet. extinct ray
 guitarfish

Osteichthyes

Holostei

Lepisosteus sp.
Anomaeodus phaseolus (Hay)
Amiidae, gen. et sp. indet.

gar
 pycnodont

Teleostei

Albula sp.
Paralbula casei Estes
Enchodus cf. *E. petrosus* Cope
Stephanodus sp.
Xiphactinus audax Leidy

bonefish
 bonefish
 salmonid?
 indet. extinct taxon
 "Porthaus"

REPTILIA

Chelonia

Cryptodira

Trionychidae, gen. et sp. indet.
Cheloniidae, gen. et sp. nov.

soft-shelled turtle
 new large marine turtle

Pleurodira

Bothremys barberi (Schmidt)

"pavingstone turtle"

Archosauria

Crocodilia

Thoracosaurus neocassariensis (De Kay)
Deinosuchus cf. *D. rugosus* (Emmons)
 indet. crocodilia

gavial-like crocodile
 giant, estuarine crocodile

Ornithischia

Hadrosauridae, gen. et sp. indet.

duckbilled dinosaur

Saurischia

Theropoda, gen. et sp. indet.

carniverous dinosaur

Lepidosauria

Squamata

Platecarpus sp.
Prognathodon sp.
Halisaurus sp.
Mosasauridae, gen. et sp. indet.

mosasaur
 mosasaur
 mosasaur
 mosasaur

These are characteristic of Campanian-age Coastal Plain assemblages from New Jersey (Baird & Case, 1966), North Carolina (Miller, 1966, 1967, 1968; Baird & Horner, 1979; Case, 1979), and western Alabama (Zangerl, 1948, 1953, 1960; Langston, 1960; Russell, 1970; Applegate, 1970; Shannon, 1977). Additionally, many taxa are also known from contemporary chalk units in Kansas and South Dakota. Two apparently new taxa are present: one a very tiny sawfish represented by several rostral barbs and oral teeth (description in prep. by G. R. Case); the other, a large marine cheloniid turtle, represented by several bones from the anterior carapace and a right innominate, not attributable to any known genus (description in prep. by Donald Baird and me).

The distinctive aspects of this assemblage are the location, diversity, and relative proportions of taxa found. The most abundant reptiles are the "pavingstone turtle" *Bothremys barberi* and, surprisingly, the giant crocodile *Deinosuchus*. At least one hundred kilograms of *Bothremys* material have been recovered, apparently derived from several dozen individual animals. Similarly, the combined collections by my students, several amateur collectors, and myself, include over 60 teeth from *Deinosuchus*, and a dozen miscellaneous bones. There are no precise means to determine how many individuals are represented by these *Deinosuchus* fossils, but it is probably a sizeable number (based on varying sizes, locations, and preservation).

Mosasauro material is relatively rare (given its abundance in many contemporary marine strata) and dinosaur material is even more scarce; nonetheless, the half-dozen scraps of dinosaur bone in the collection are significant regional occurrence records. No plesiosaur or pterosaur fossils have yet been found in the Blufftown. (However, two bones from a large pterosaur have been recently described from the Eutaw Formation near the study area; see Schwimmer *et al.*, 1985.)

Among the megascopic fish fossils, the shark taxon *Scapanorhynchus tezanus* comprises over 90% of the material, represented by several thousand teeth and vertebrae. A surprisingly large amount of material from the sawfish *Ischyrohiza mira mira* is also present, along with numerous teeth from *Xiphactinus audax* (these reach lengths of nearly three inches and may be mistaken for plesiosaur teeth). All other megascopic fish materials are relatively rare; nevertheless, virtually any quantity of sieved sediment will contain at least a half-dozen microscopic oral teeth from the various rays, hybodont sharks, and pycnodont bony fish listed.

Paleoenvironmental Implications

The following discussion presents chronological scenarios on the depositional and paleoenvironmental histories of the few meters of Blufftown strata exposed along Hannahatchee Creek. The units shown in Figure 1 will be used as time-stratigraphic references.

Units 1 and 2 times represent intervals of typical, low-energy, back-barrier environmental conditions (very much like prevailing environments of deposition for the entire upper Blufftown Formation). Fossils are not common and these include mostly intact *Exogyra* valves and other large bivalve shells, many with sponge borings. Large ammonites (*Placentoceras* sp.) are abundant locally, and these suggest free communication with the hemipelagic realm. Shark teeth are relatively common, but no more so than in typical Coastal Plain sediments. Fossils of other vertebrates are rare in this unit but, when found, tend to occur in large pieces. The well-preserved *Platycarpus* dentary material (Plate 2, Fig. J) and the carapace from the new cheloniid turtle (Plate 2, Fig. D) came from these units. Since the characteristic vertebrates (i.e., sharks, mosasaurs,

and sea-turtles) are fully-marine creatures, their occurrences support the contention of normal marine conditions within the back-barrier lagoon. In summary, Units 1 and 2 were deposited during times of relatively high water, with little fluvial influence, and represent soft, slightly eutrophic bottom substrates which inhibited habitation by many benthonic organisms.

Unit 3 represents the onset of a regressive period. Water depths were sufficiently shallow to allow storms to rip up the sediment and redeposit bivalve shell-hash and *Hamulus* tubes in numerous thin, graded sequences. Inconclusive evidence of increased freshwater influence is provided by many lingulid valves, in good condition, interbedded with the shell hash. The Blufftown lagoon at this stage apparently was shallowing and approaching subaerial exposure. Freshwater may have been entering as storm runoff or via rivers.

Unit 4 represents a continuation of the regression, during which deposits of the old lagoon were succeeded by deposits of a tidal marsh which were exposed to subaerial weathering at low tide. The *Crassostrea* bioherm developed for a brief period, and a host of creatures lived on and around it, and probably were nourished by it. The very-shallow-water environment supported an unusually large and diverse vertebrate fauna, notably including many *Bothremys* turtles and a few duckbilled dinosaurs. Many estuarine crocodiles, including gigantic (dinosaur-eating) taxa, smaller fish-eating taxa, and rare carnivorous dinosaurs, preyed on the other large inhabitants. Fully marine vertebrates (mosasaurs, larger sharks, larger sea-turtles) are represented only by isolated teeth, suggesting that the fossils are derived from beached or wave-carried carcasses. Forests on nearby barrier bars and the fringes of salt marshes yielded abundant driftwood. There is a significant non-marine biota present, including trionychid turtles, the driftwood, the crocodiles, and the dinosaurs; however, the mollusks in the sediment indicate normal-marine salinities. In summary, therefore, a river probably debouched near the study area, but at sufficient distance so that the local waters maintained normal marine salinities; the general environment might best be classified as estuarine at this stage.

Unit 5 represents a back-barrier beach, indicating the maximum stage of regression during this cycle. The sand includes abundant, megascopically-recognizeable mollusk fragments and suggests that wave energies were only moderate.

Unit 6 time represents a slight rise of sea level. The diversity and abundance of intact marine invertebrate fossils is highest in this unit, suggesting that the estuary was at optimum depths for benthonic inhabitants, and that storms did not characteristically tear up the bottom. Nevertheless, some shell-hash zones are present, and several localities feature sizeable concentrations of abraded shark, crocodile, and mosasaur teeth, and water-rounded marine and non-marine reptile bone fragments. Thus, sea level was still sufficiently low for storms to reach bottom on occasions, followed by long quiet-water intervals during which the reworked bone was current-concentrated and redeposited.

Units 7 through 9 contain alternating equivalents of units 1 through 4 (although without recurrence of the erosional surface in unit 4) and unit 6, suggesting that generally higher, but unstable, sea levels prevailed through the rest of Blufftown time. The erosional surface above unit 9 represents either the termination of Blufftown deposition, or post-depositional erosion; the interpretation depends heavily on the nature of unit 10, which is presently under study. It may be either part of the Cusseta Formation (thereby indicating renewed Late Cretaceous transgression) or a post-Cretaceous terrace deposit. The sediment in unit 10 (light-colored, medium sand) generally resembles that of unit 5; however, this resemblance could be due to reworking of older material. Further study hopefully will elucidate the history of the absolute uppermost Blufftown and overlying units in the study area.

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References Cited

- APPLEGATE, S. P. 1970. The vertebrate fauna of the Selma Formation in western Alabama. Part VIII: The fishes. *Fieldiana: Geological Memoirs*, 3:383-433.
- BAIRD, D., and G. R. CASE. 1966. Rare marine reptiles from the Cretaceous of New Jersey. *Journal of Paleontology*, 40(5):1211-1215.
- CASE, G. R. 1979. Cretaceous selachians from the Peedee Formation (Late Maestrichtian) of Duplin County, North Carolina. *Brimleyana*, 2:77-89.
- COOKE, C. W. 1943. *Geology of the Coastal Plain of Georgia*. U.S. Geological Survey, Bulletin 941, 121 pp.
- COPE, E. D. 1878. Paleontology of Georgia. *American Naturalist*, 12(2):128.
- EARGLE, D. H. 1955. *Stratigraphy of outcropping Cretaceous rocks of Georgia*. U.S. Geological Survey, Bulletin 1014, 101 pp.
- HAY, O. P. 1908. *Fossil turtles of North America*. Carnegie Institution of Washington, Publication 75, Pt. 4, 568 pp.
- HERRICK, S. M., & P. E. LAMOREAUX. 1944. *Upper Cretaceous Series (of the southwest Georgia Coastal Plain*. Georgia Geological Society, Guidebook, Annual field trip.
- HORNER, J. R. 1979. Upper Cretaceous dinosaurs from the Bearpaw Shale (marine) of south-central Montana with a checklist of Upper Cretaceous dinosaur remains from marine sediment in North America. *Journal of Paleontology*, 53(3):566-577.
- LANGSTON, W., Jr. 1960. The vertebrate fauna of the Selma Formation of Alabama. Part VI: The dinosaurs. *Fieldiana: Geological Memoirs*, 3:319-360.
- LERMAN, A. 1965. Evolution of *Esogyra* in the Late Cretaceous of the southeastern United States. *Journal of Paleontology*, 39(3):414-435.
- LULL, R. S., & N. E. WRIGHT. 1942. *Hadrosaurian dinosaurs of North America*. Geological Society of America, Special Paper 40, 242 pp.
- MARSALIS, W. E., & M. S. FRIDDELL. 1975. *A guide to selected Upper Cretaceous and Lower Tertiary outcrops in the lower Chattahoochee River Valley of Georgia*. Georgia Geological Society Guidebook 15, 88 pp.
- MILLER, H. W. 1966. Cretaceous vertebrate fauna from the Phoebus Landing, North Carolina. *J. Elisha Mitchell Scientific Society*, 82(2):1.
- . 1967. Cretaceous vertebrate faunas from Phoebus Landing, North Carolina. *Academy of Natural Sciences of Philadelphia, Proceedings*, 119(5):219-235.

- . 1968. Additions to the Upper Cretaceous vertebrate fauna of Phoebus Landing, North Carolina. *J. Elisha Mitchell Scientific Society*, 84(4):467-471.
- RICHARDS, H. G., & B. M. HAND. 1958. Fossil shark teeth from the Coastal Plain of Georgia. *Georgia Mineral Newsletter*, 11(3):91-94.
- RUSSELL, D. A. 1970. The vertebrate fauna of the Selma Formation in Alabama. Part VII: The mosasaurs. *Fieldiana: Geological Memoirs*, 3:363-380.
- SCHWIMMER, D. R. 1981. A distinctive Upper Cretaceous fauna, 3-4 meters below the Blufftown-Cusseta contact in the Chattahoochee River Valley. In: J. Reinhardt & T. G. Gibson, *Upper Cretaceous and Lower Tertiary geology of the Chattahoochee River Valley, western Georgia and eastern Alabama*. Georgia Geological Society, 16th Annual Field Trip, Guidebook, pp. 81-88.
- SCHWIMMER, D. R., K. PADIAN, & A. B. WOODHEAD. 1985. First pterosaur record from Georgia: Open marine facies, Eutaw Formation (Santonian). *Journal of Paleontology*, 59(3):674-676.
- SHANNON, S. W. 1977. The occurrence and stratigraphic distribution of mosasaurs in the Upper Cretaceous of west Alabama [abstract]. *Geological Society of America, Abstracts with Programs*, 12(1):184.
- SOHL, N. F., & E. G. KAUFFMAN. 1964. *Giant Upper Cretaceous oysters from the Gulf Coast and Caribbean*. U.S. Geological Survey, Professional Paper 483-H, 22 pp.
- STEPHENSON, L. W. 1911. Cretaceous (rocks of the Coastal Plain). In: J. O. Veatch & L. W. Stephenson, *Preliminary report on the geology of the Coastal Plain of Georgia*. Georgia Geological Survey, Bulletin 26, pp. 66-215.
- . 1914. *Cretaceous deposits of the eastern Gulf region and Species of Exogyra from the eastern Gulf region and the Carolinas*. U.S. Geological Survey, Professional Paper 81, pp. 9-40, 41-74.
- ZANGERL, R. 1948. The vertebrate fauna of the Selma Formation in Alabama. Part I: Introduction. Part II: The pleurodire turtles. *Fieldiana: Geological Memoirs*, 3:3-56.
- . 1953. The vertebrate fauna of the Selma Formation in Alabama. Part III: The turtles of the Family Protostegidae. Part IV: The turtles of the Family Toxochelyidae. *Fieldiana: Geological Memoirs*, 3:61-277.
- . 1960. The vertebrate fauna of the Selma Formation in Alabama. Part V: An advanced cheloniid sea turtle. *Fieldiana: Geological Memoirs*, 3:281-310.

PLATE I

Representative fish fossils and distinctive oysters from the study area.

Most specimens from the erosional horizon in unit 4 (Fig. 1), except specimens N which come from upper beds of unit 4. All catalog numbers refer to Columbus College collections.

- A *Scapanorhynchus texanus* (Roemer). Positions of teeth shown are: *a*, anterior; *b*, extreme lateral; *c*, *d*, mid-lateral. All specimens X 1.
- B *Squalicorax kaupi* (Agassiz). Positions of teeth shown are: *a*, anterior; *b*, mid-lateral; *c*, lateral. All specimens X 1.
- C *Cretolamna appendiculata lata* (Agassiz). Positions of teeth shown are: *a*, extreme lateral; *b*, mid-lateral; *c*, anterior. All specimens X 1.
- D *Ischyroiza mira mira* Leidy. *a*, *b*, rostral (saw) teeth (X 1), CCK-83-88-1,2; *c*, *d*, oblique and occlusal views of an oral tooth (X 20).
- E *Hybodus* sp., cephalic hooks. Above, ventral view of specimen CCBCK-82-3-2 with anterior tip missing; below, oblique-lateral view of CCBCK-82-3-3, a more complete hook. Both X 1.
- F *Ptychotrygon vermiculata* Capetta. Two views of oral tooth; above, oblique-posterior; below, occlusal view. Both X 20.
- G *Enchodus* cf. *E. petrosus* Cope. Anterior tooth, COBBK-116-9-1; X 1.
- H, I *Xiphactinus audax* Leidy. H, anterior tooth, CCK-85-2-1; I, dorsal vertebra, CCK83-81-8. Both X 1.
- J *Lepisosteus* sp. Isolated scale, CCBCK-83-2-1; X 1.
- K *Anomacodus phaseolus* (Hay). Two views of pharyngeal tooth element; above, occlusal; below, basal. Both X 25.
- L, M, O *Crassostrea cussata* Sohl & Kauffman. L, nearly complete right valve, CCK-85-5-73, X 0.3; M, nearly complete right valve in bioherm facies, knife for scale is 16 cm long; O, *Crassostrea cussata* bioherm surface, showing individuals cemented together laterally and at various attitudes, knife for scale is 12.5 cm long.
- N *Esogyra ponderosa* var. *erraticostata* Stephenson. Above, large individual with ornamentation partly ablated (X 0.4), CCK-82-3-4; below, specimen showing strong ornamentation (X 0.5), CCK-86-7-2.

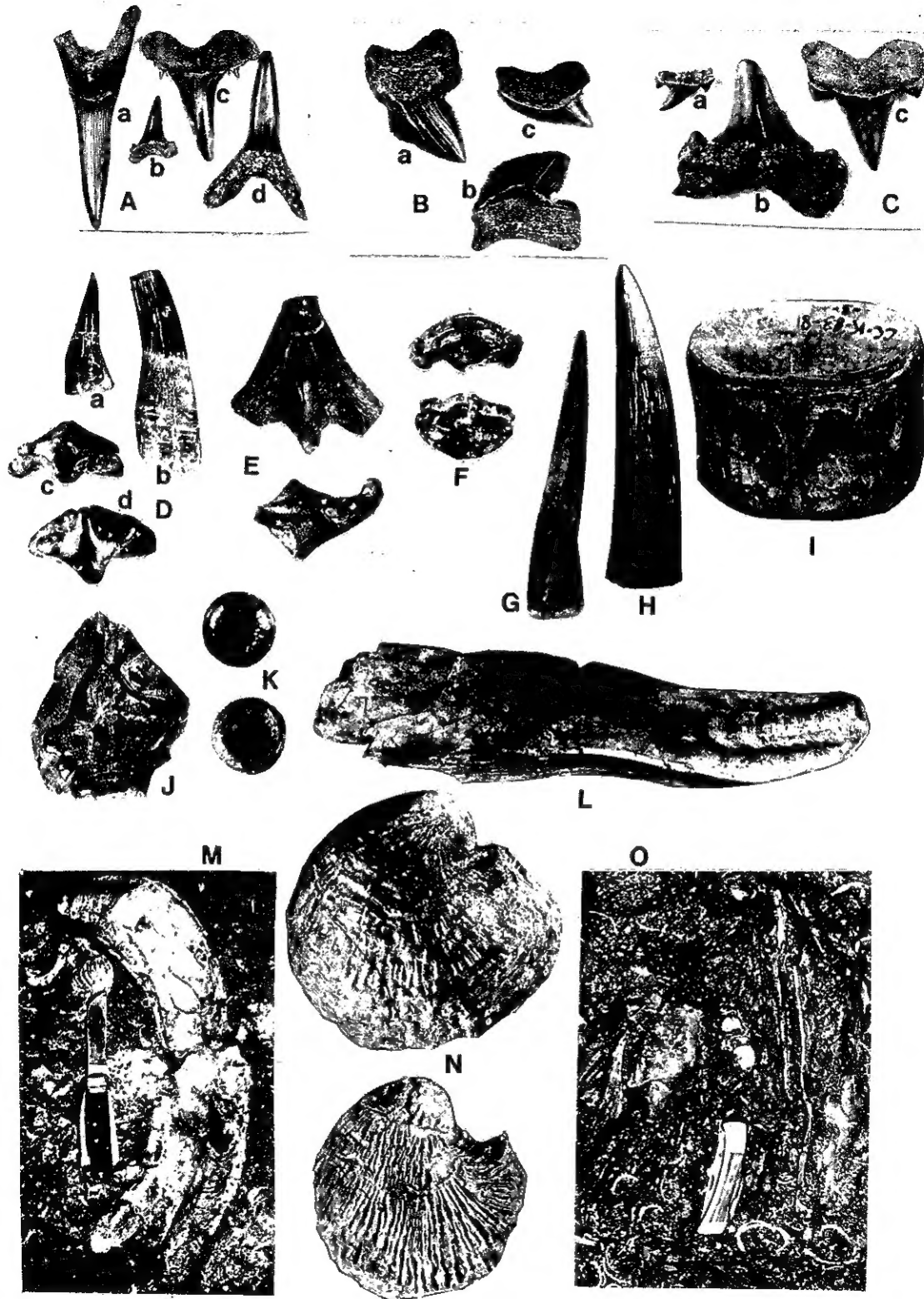


PLATE II

Representative reptile fossils from the study area.

All specimens from the erosional horizon in unit 4 (Fig. 1) except D and J, which are from unit 2. All catalog numbers refer to Columbus College collections.

- A, B *Hadrosauridae*, gen. et sp. indet. A, water-rounded fragment of left, posterior dentary, in labial (left) and lingual (right) views; with traces of the alveoli for six posterior teeth are visible in the right photograph (X 0.5), CCK-79-3-1; B, fragments of limb bones, from indeterminable positions (X 0.3), CCBBK-111-1,2.
- C *Trionyx* sp. Costal fragment, showing characteristic ornamented surface (X 0.7), CCK-79-4-1.
- D *Cheloniidae*, gen. et sp. nov. Reconstruction of anterior carapace from fragments of nuchal and peripheral bones (X 0.2), CCK-79-4-1.
- E, F *Bothremys barberi* (Schmidt). E, ventral view of first three costals of the left carapace (X 0.3), CCBK-83-1-2; F, vertebral bone (X 0.75), CCSSK-81-7-1.
- G, H *Deinosuchus* cf. *D. rugosus* (Emmons). G, anterior or anterolateral tooth, CCK-85-3-3; H, posterior tooth, tip ablated, CCCTK-84-11-1. Both X 0.8.
- I *Thoracosaurus neoccsariensis* (De Kay). Left dentary fragment with four tooth alveoli (X 0.75), COBBK-112-1.
- J *Platecarpus* sp. (Left), anterior fragment with single tooth and replacement alveolus, COBOK-4-1; (Right), mid-jaw fragment with two teeth, CCK-82-23-1. Both specimens from left dentary of same individual, X 0.7.
- K *Prognathodon* sp. Isolated tooth, showing smooth enamel with fine striations and extremely fine serrations on the anterior carina (X 0.9), CCDHK-84-14-1.
- L *Halisaurus?* sp. Water-rounded vertebra (X 0.75), CCDHK-84-14-2.

